Intersection Design

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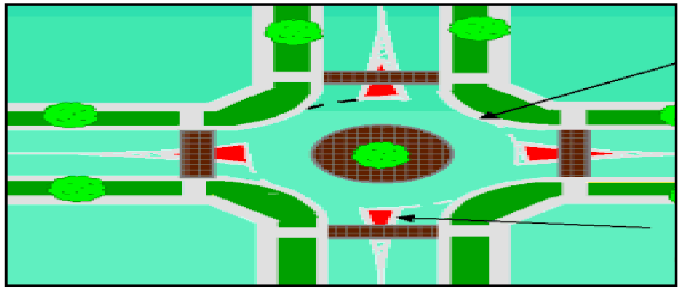
FAE_ZUN

2011

Intersection Design

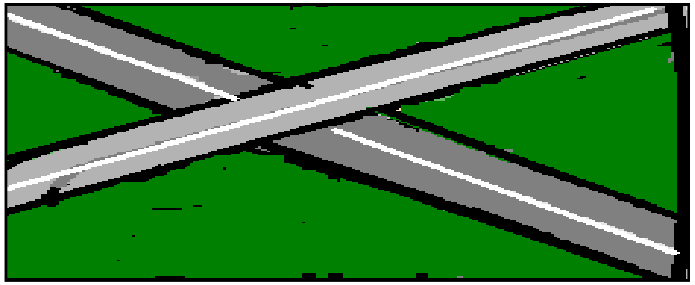
- Intersection Types
- Provide adequate **sight distance** – for approach and departure maneuvers
- Minimize turning and through **conflicts**
- Avoid geometry (**sharp curves/steep grades**) that adversely impact acceleration/deceleration

Types of Intersections



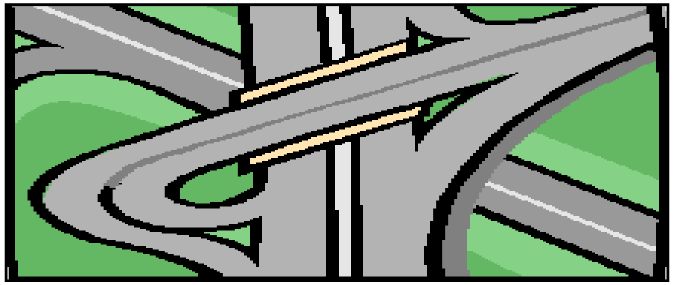
At Grade Intersection

(at same level)



Grade Separation

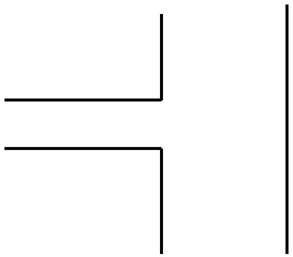
(Highway levels are not connected)



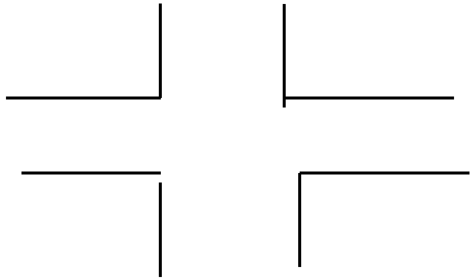
Interchange

(Highway levels are connected)

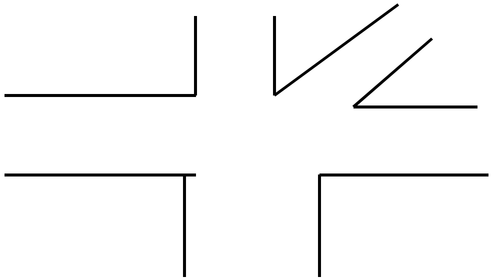
At Grade Intersections



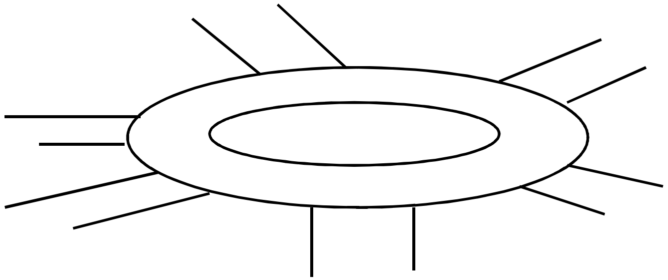
Three-leg intersections



Four-leg intersections



Multi-leg intersections



Roundabout intersections

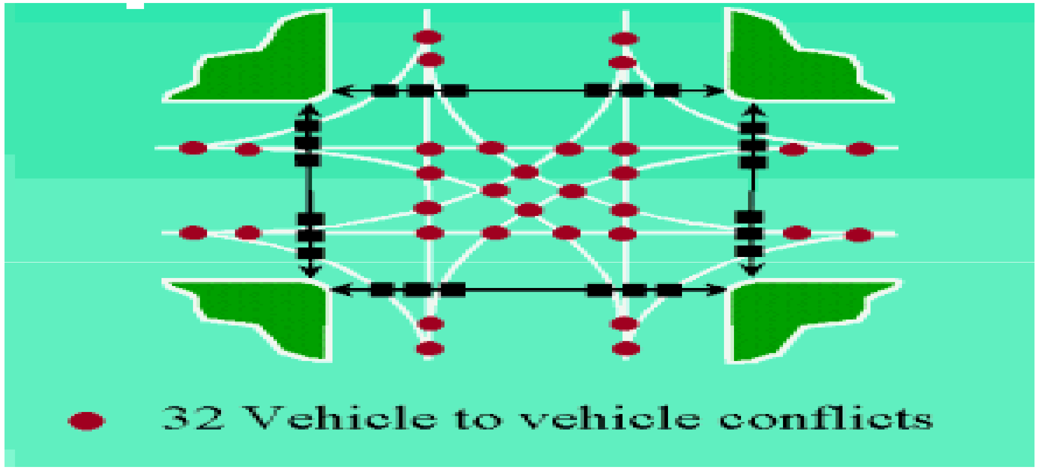
Conflict points

There are three types of conflict points as follows

-Merging points

- Diverging points

- Crossing points

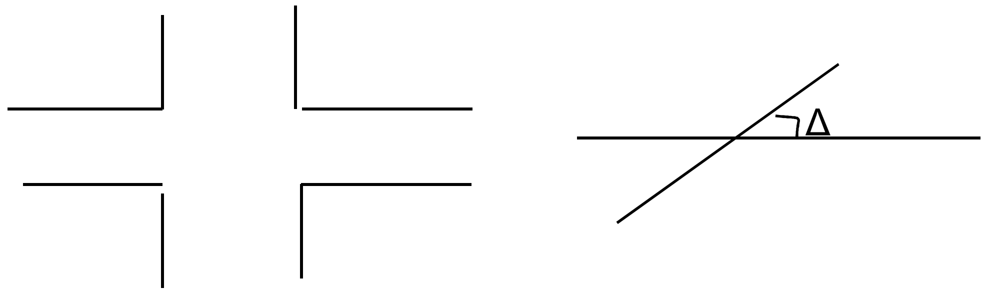


For 4-Leg intersection as shown in the figure, the conflict points are

At Grade Intersection

Three-leg or four-leg at grade intersection are designed as plain, flared and fully channelized. It will be discussed in the following:

1) Plain



Design Elements	Advantages	Disadvantages
-Right turn (simple)	- Small area	-Delay due to R.T, L.T
Table (1)	- Simple design	-Conflict between R.T and through
	- Small cost	-Undefined path for L.T, R.T

Angle	Vehicle	Simple Curve (m)	Angle	Vehicle	Simple Curve (m)
30	PC	18	105	PC	6 – 0.75 – 8:1
	SUT	30		SUT	11 – 0.9 – 10:1
	WB-40	45		WB-40	12 – 1.2 – 10:1
45	PC	15	120	PC	6 – 0.6 – 10:1
	SUT	23		SUT	10 – 0.9 – 10:1
	WB-40	37		WB-40	11 – 1.5 – 8:1
60	PC	12	135	PC	6 – 0.45 – 15:1
	SUT	18		SUT	9– 1.2 – 8:1
	WB-40	27		WB-40	10 – 2.4 – 6:1
75	PC	7.5 – 0.6 – 10:1	150	PC	5.5 – 0.6 – 10:1
	SUT	13.5 – 0.6 – 10:1		SUT	10 – 1.2 – 8:1
	WB-40	18 – 0.6 – 15:1		WB-40	10 – 1.8 – 8:1
90	PC	6 – 0.75 – 10:1	180	PC	4.5 – 0.15 – 20:1
	SUT	12 – 0.6 – 10:1		SUT	10 – 0.45– 10:1
	WB-40	13.5 – 1.2 – 10:1		WB-40	6 – 2.9– 5:1

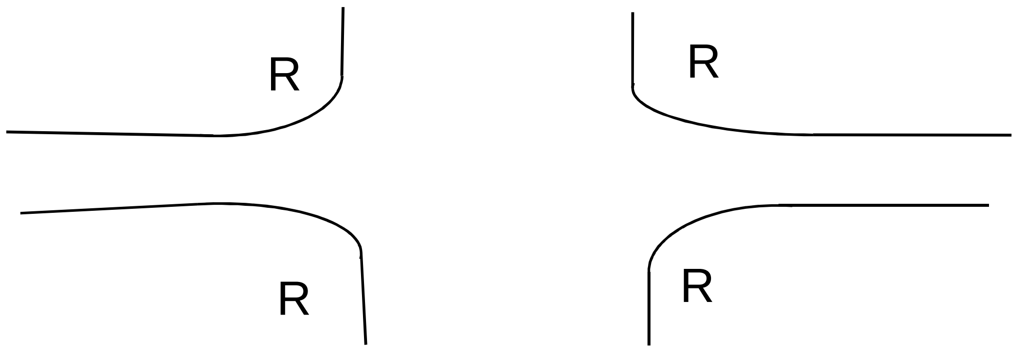
1) Plain

Design of right turns for plain intersection type

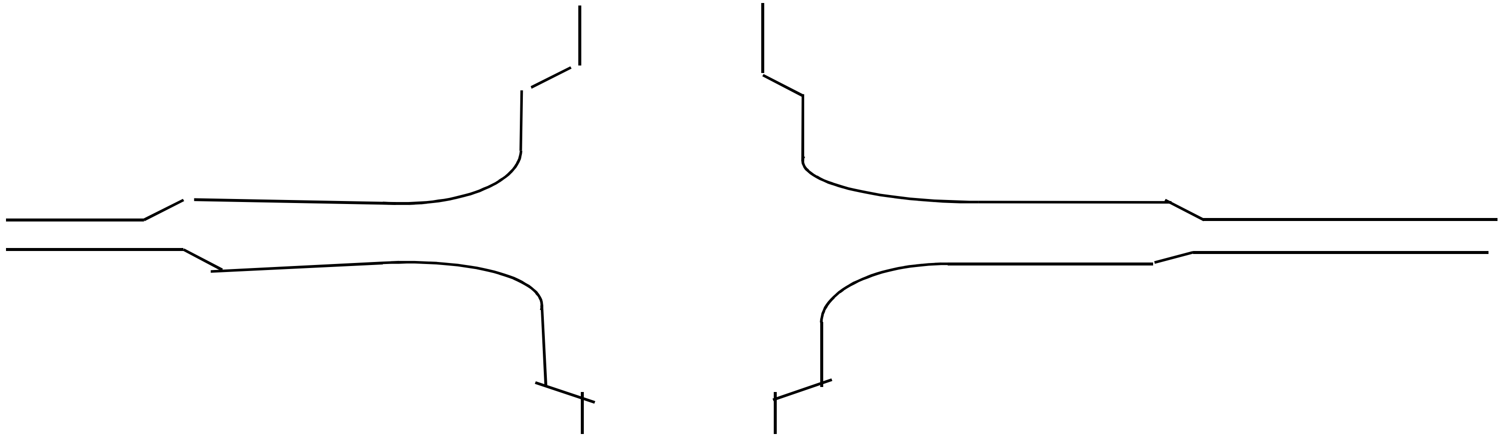
-Factor affecting right turn design includes turning angle (deflecting angle) and design vehicle

-Turning angle (Δ) is measured as shown in figure.

-Design vehicle is classified into (PC, SUT, Trailer WB-40, WB-50).



2) Flared



Design Elements

-Right turn (simple)

Table (1)

-Speed change lanes

Advantages

- Moderate area and cost

- No delay due to R.T

Disadvantages

-Delay due to L.T

-Undefined path for L.T

2) Flared

<u>Design of right turns</u>

The same procedure followed for plain intersection

<u>Design of speed change lanes</u>

Deceleration and acceleration lanes can be calculated as follows:

-Total deceleration lane = Lt + Ld

Lt = 0.278Vt

Ld= from Table (2)

$Ld = 0.295\,(V^2_1 - V^2_2)\,/\,d$ (d = 8 kph/sec)

-Total Acceleration lane = Lt + La

Lt = 0.278Vt

La= from Table (2)

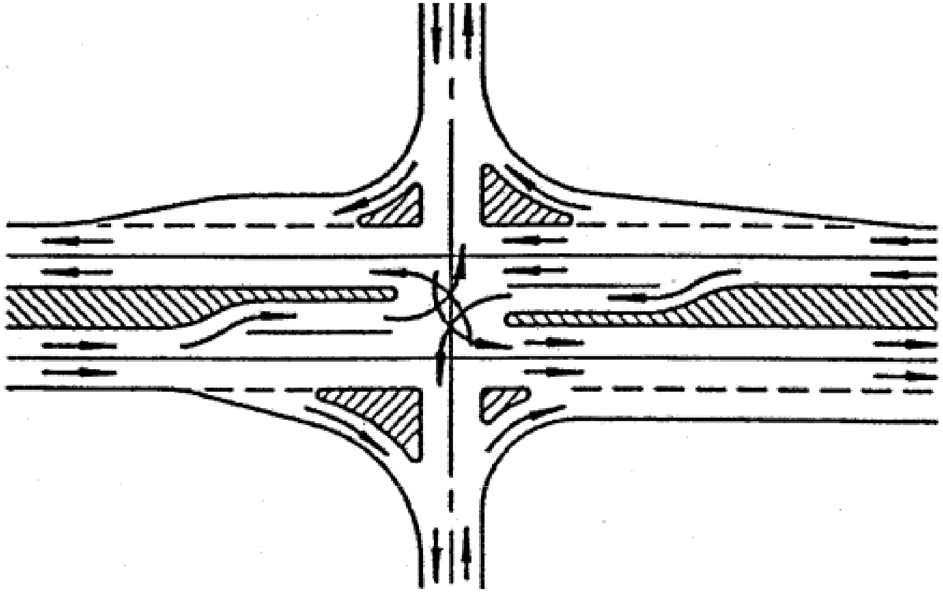
$La = 0.295\,(V^2_1 - V^2_2)\,/\,a$ (a = 5 kph/sec)

Design Speed	Acceleration length (m) for entrance design speed (km/hr)								
	0.0	25	30	40	50	55	65	70	80
50	60	-	-	-	-	-	-	-	-
65	115	100	75	65	45	-	-	-	-
80	230	215	190	175	150	115	50	-	-
95	355	340	325	305	275	245	180	120	50
115	485	470	455	430	405	375	310	255	175

Design Speed	Deceleration length (m) for entrance design speed (km/hr)								
	0.0	25	30	40	50	55	65	70	80
50	70	55	50	45	-	-	-	-	-
65	95	90	80	70	55	45	-	-	-
80	135	125	115	110	95	85	70	55	-
95	160	150	150	140	130	125	105	90	75
105	175	165	160	150	145	130	115	100	85
115	185	180	175	170	155	150	130	120	105

Design Length of speed change lane for all main highway flat grades 2% or less

3) Fully Channelized



Design Elements

-Right turn

-Speed change lanes

-Pocket lanes

Advantages

- Defined path for left turn

- No delay due to R.T

Disadvantages

-Large area and cost

3) Fully Channelized

Design of right turns (turning roadway)

Table (3) used to design turning roadway depends on turning speed - low (up to 20kph) - high (more than 20kph)

Design of speed change lanes

- Deceleration and acceleration lanes (the same procedure followed for flared type

Design of pocket lanes

- Pocket lane = Lt+ Ld+ Ls

- Ls = 30m

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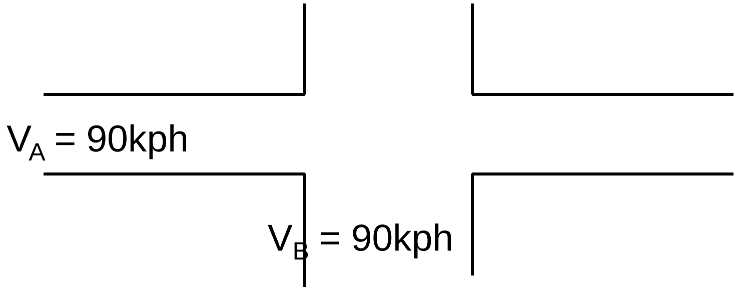
Example

- It is required to design the shown intersection in the figure as:

  Plain Flared Fully channelized

If the design vehicle is SUT and turning speed V= 25 kph



Solution

<u>1-Plain</u> Δ=90, SUT Table (1)

15m, 12/0.6/10:1, 40-12-40/0.6

<u>2- Flared</u> Δ=90, SUT Table (1)

15m, 12/0.6/10:1, 40-12-40/0.6

Speed change lane

Lt = 65m La = 280 m, Ld = 138 m

3- Fully channelized, T.speed = 25 kph (high turning speed)

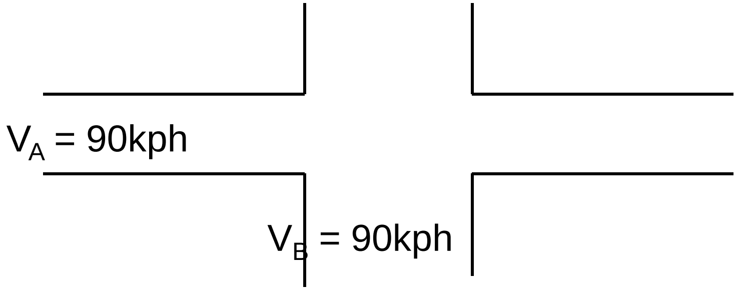
R = 15 m, 1-lane 1-way, Pavement width=5.5 m

Speed change lane

Lt = 65m , La = 280 m, Ld = 138 m

Pocket lane

Lt = 65m , Ld = 138 m, Ls = 30 m

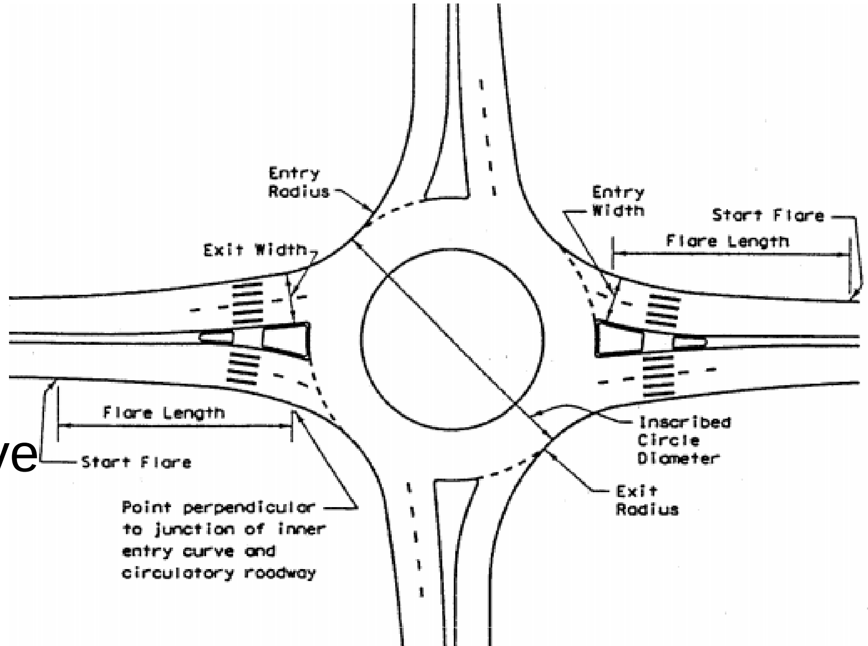


4) Roundabout

The roundabout is a channelized intersection with one-way traffic flow circulating around a central island

•**Size** – Single lane roundabouts have an outside diameter 45m.

•**Speed** – The small diameter of roundabouts limits circulating vehicle speeds to 40kph



Sight Distance

- Allow drivers to have an **unobstructed** view of intersection
- **SD** is the **length** of cross road that must be visible such that the driver of a turning/crossing vehicle can **decide** to and **complete** the maneuver without conflict with vehicles approaching the intersection on the cross road.

Sight Distance

- **Sight Triangle** – area free of obstructions necessary to complete maneuver and avoid collision – **needed for approach and departure.**
- Allows driver to anticipate and avoid collisions
- Allows drivers of stopped vehicles enough view of the intersection to decide when to enter

Sight Triangle

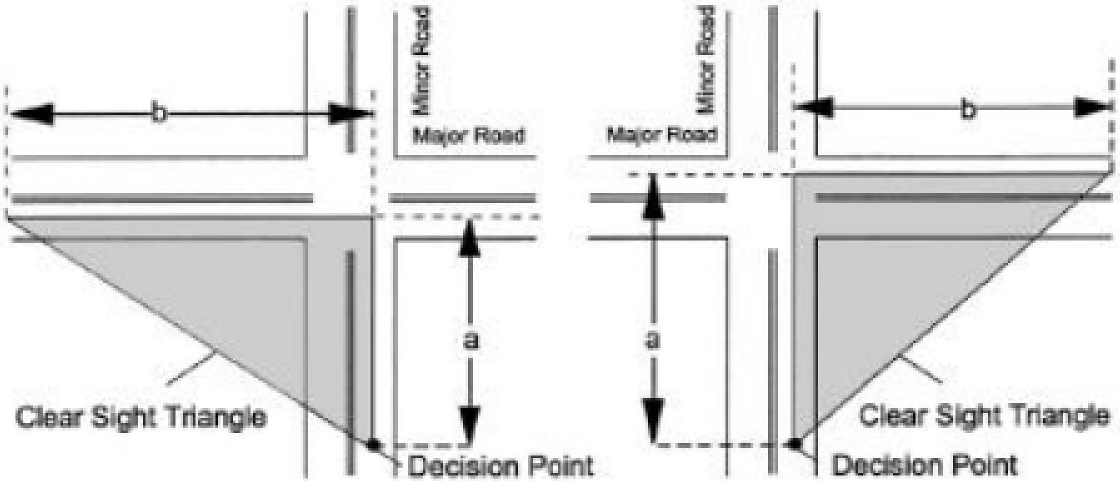
- Area free of obstructions necessary to complete maneuver and avoid collision – **needed for approach and departure.**
- Consider horizontal as well as vertical, object below driver eye height may not be an obstruction
- AASHTO assumes **1.05 m** above roadway of an object height of **1.3 m**

Sight Triangle

Case	Approach Triangle	Depart. Triangle
A. No control	Required	Required
B. Stop control	Not required	Required
C. Signal control	Not required	Not required

Uncontrolled intersections do not normally require departure sight triangles because they typically have very low traffic volumes.

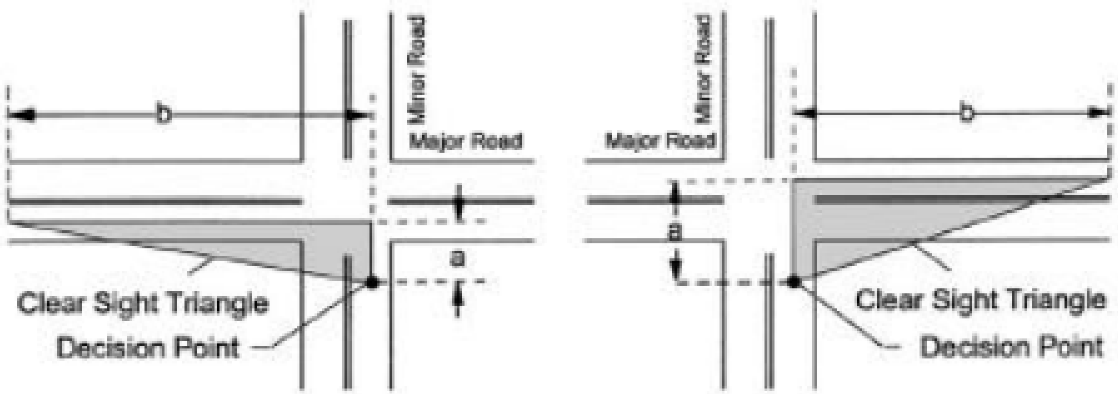

Hidden Vehicle



Clear Sight Triangle for Viewing Traffic Approaching from the Left

Clear Sight Triangle for Viewing Traffic Approaching from the Right

A -- Approach Sight Triangles



Clear Sight Triangle for Viewing Traffic Approaching from the Left

Clear Sight Triangle for Viewing Traffic Approaching from the Right

B -- Departure Sight Triangles


STOP

SD Cases

- **No control**: vehicles adjust speed
- **Stop control**: where traffic on minor roadway must stop prior to entering major roadway
- **Signal control**: where vehicles on all approaches are required to stop by either a stop sign or traffic signal

Case A – No Control

- **Rare?** – Not really
- Minimum sight triangle sides = distance traveled in **3 seconds** to adjust their speed

$$(d_a = 0.278 \times v_a \times t), (d_b = 0.278 \times v_b \times t)$$

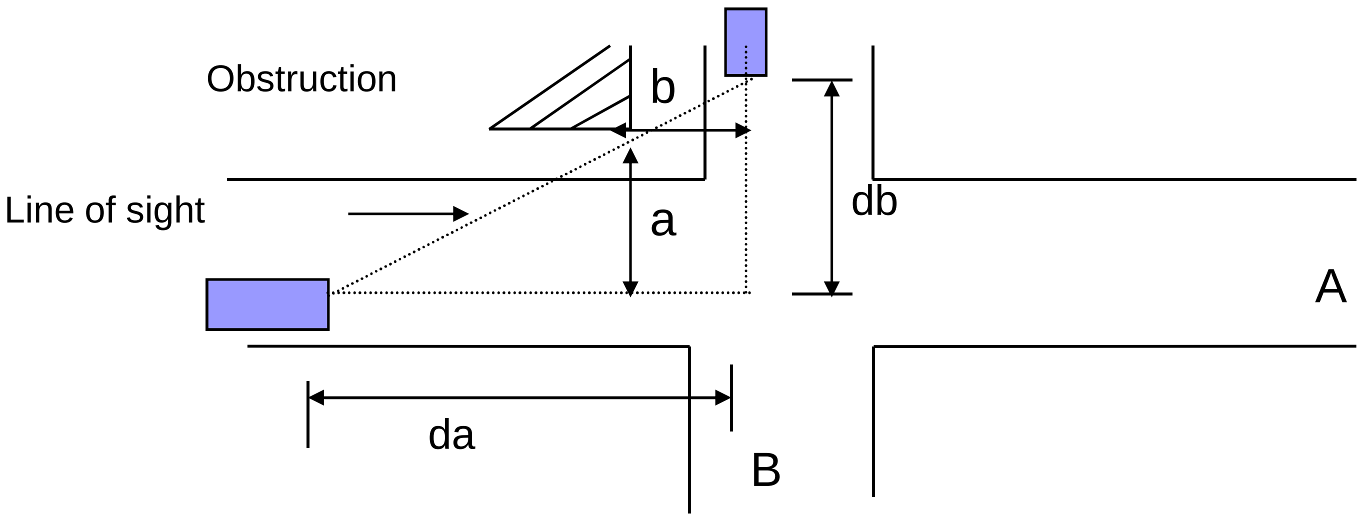
Case A – No Control

- **Prefer** appropriate SSD on both approaches (minimum really)
- Provided on **lightly traveled** roadways
- Provide **control if sight triangle not available**
- Assumes vehicle on the left yields to vehicle on the right if they arrive at same time

Minimum Distance for Sight Triangle: **No Control**

Speed (kph)	Distance (m)
20	20
30	25
40	30
50	40
60	50
70	65
80	80
90	95
100	120
110	140
120	165

Case A – No Control



$(d_a-b)/d_a = a/d_b$

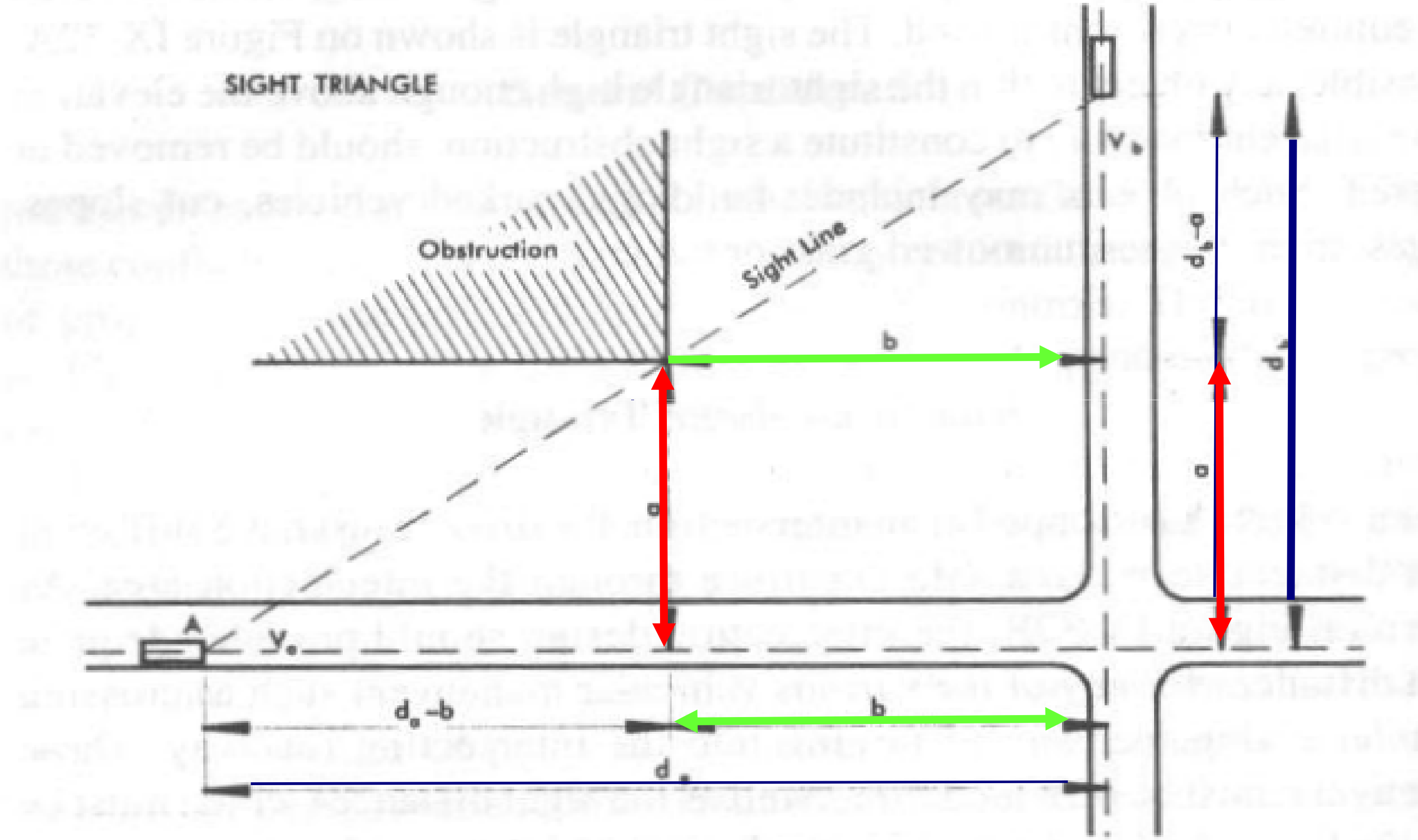
$a*d_a = d_b(d_a-b)$

$d_b = a*d_a/(d_a-b)$

$d_a = 0.278*V_a*t$

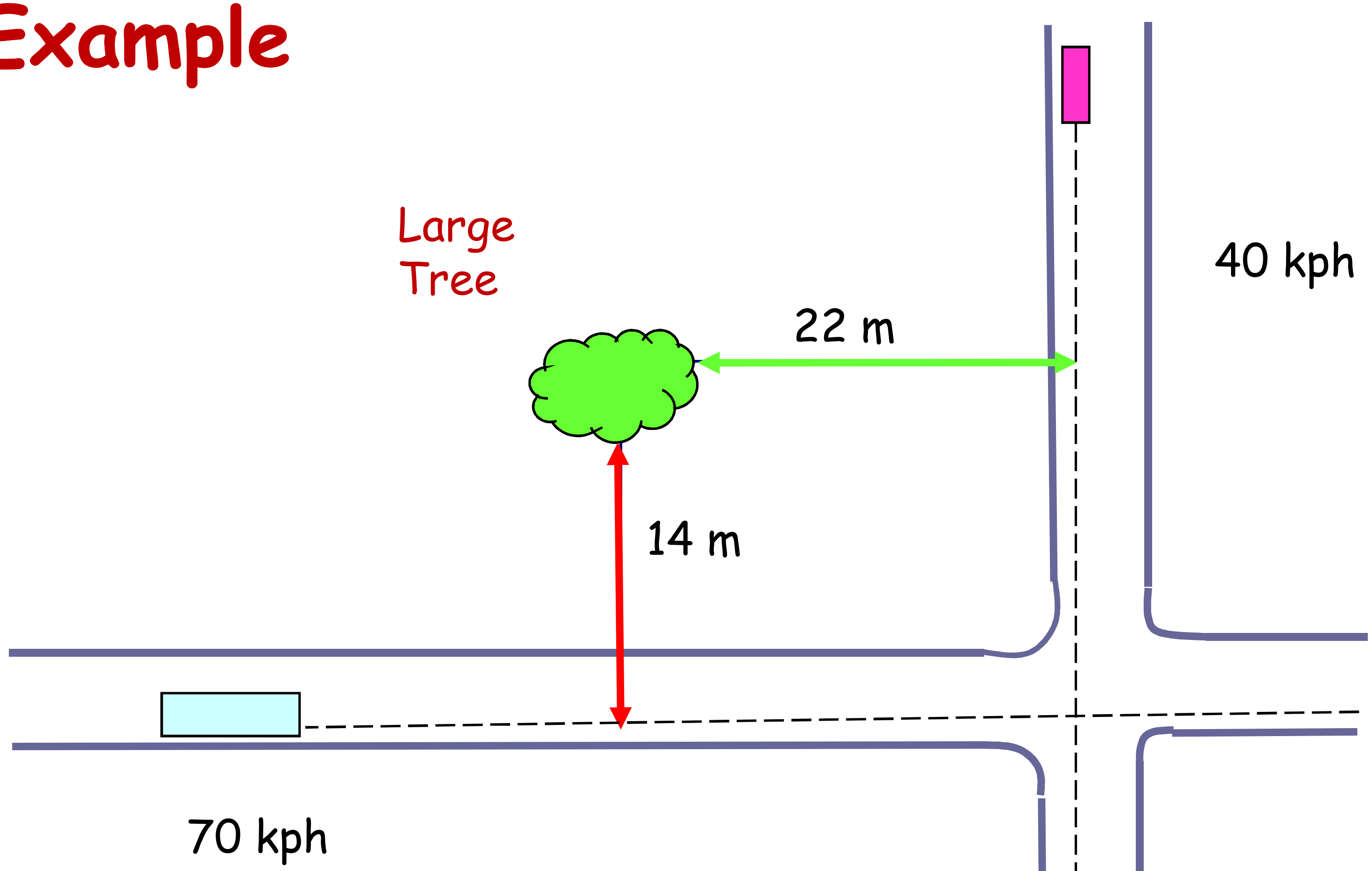
$d_b = 0.278*V_b*t$ (t = 3sec)

Case A – No Control



Critical speed is set to stopping distance $d_b = a \dfrac{d_a}{d_a - b}$

Example



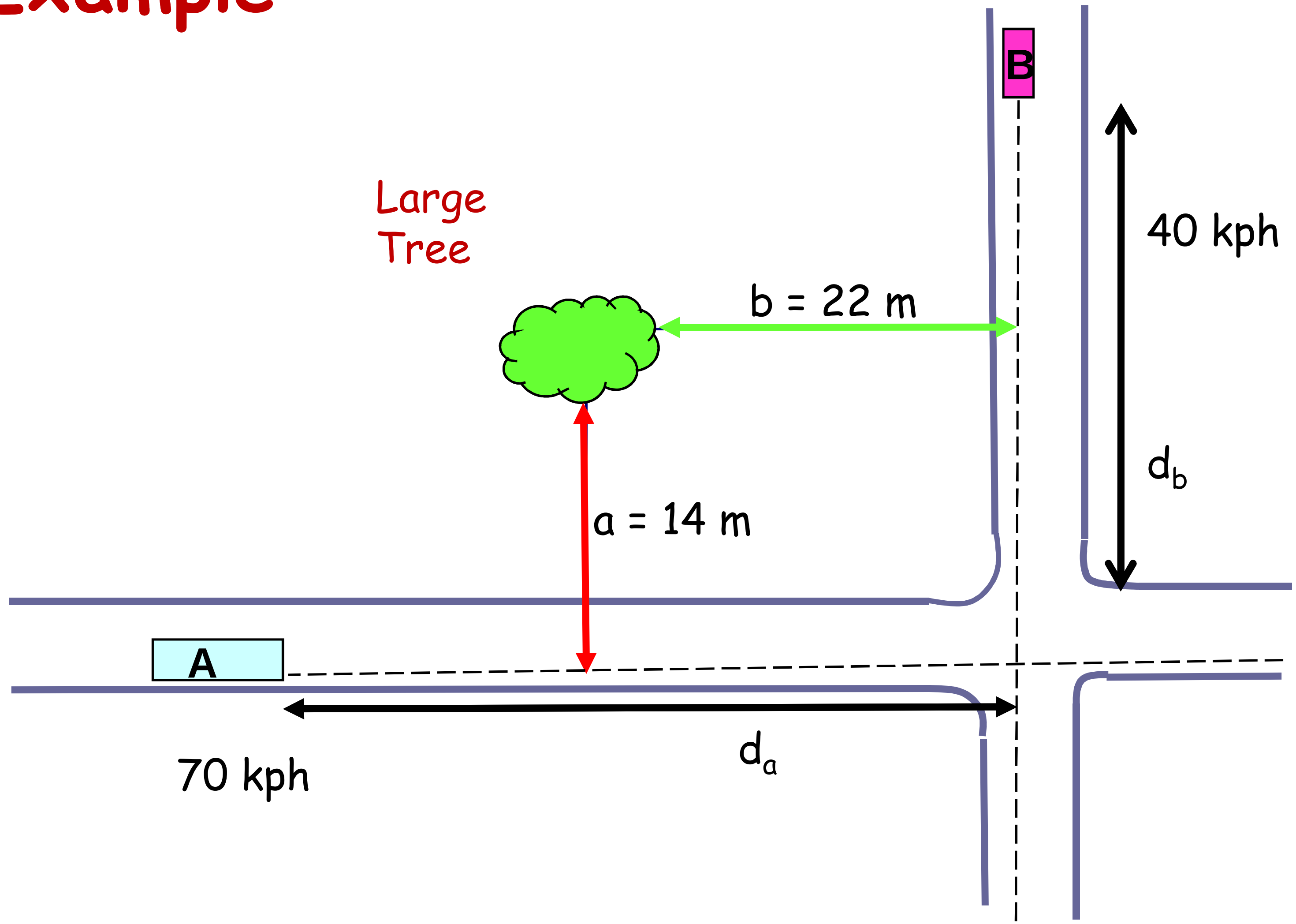
Is sufficient stopping sight
distance provided?

Speed (kph)	Distance (m)
20	20
30	25
40	30
50	40
60	50
70	65
80	80
90	95
100	120
110	140
120	165

$d_b = 30$ m

$d_a = 65$ m

Example



Case B – Stop Control

Three Sub Cases – Maneuvers

- **Turn left** on to major roadway (clear traffic left, enter traffic right)
- **Turn right** on to major roadway (enter traffic from left)
- **Crossing** (clear traffic left/right)

Case B – Stop Control

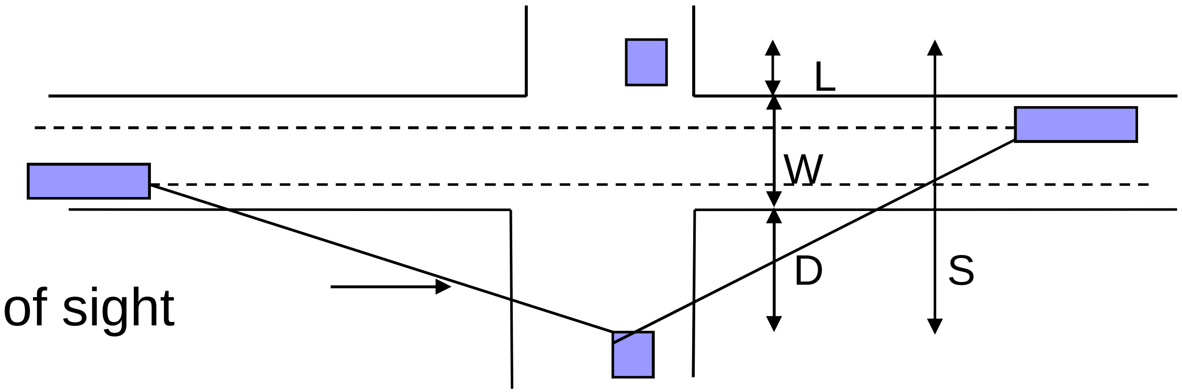
- Need SD for departure and completion even if vehicle comes into view at point of departure:-

$$SD = 0.278\ V_{major} * t_g$$

where t_g**=7.5-11.5s**; add more for grade or multilane; decrease by **1s.** for right turns

Case B – Stop Control

Intersection controlled by stop sign on minor road



Line of sight

$S = L+D+W$

$D = 0.28V(J+ta)$

J = startup time=2sec

Case B – Stop Control

Values of time (ta) required for the vehicle to cross the width S

Design Vehicle	S (m)					
	18	24	30	37	43	49
PC	5.25	6.1	6.8	7.6	8.25	8.90
SUT	7	8.2	9.2	10.2	11.10	11.90
Se.Tr.	8.3	9.6	10.9	12	13.10	14.20

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Any Questions?